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On the development of a computer based diagnostic assessment tool to help in teaching and learning process

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ABSTRACT

This paper presents a computer based diagnostic tool developed to facilitate the learning process. The developed tool is capable of generating possible error syndromes associated with the answers received. The developed tool simulates the error pattern of the test results and then accordingly models the action plan to help in children's learning process. The built-in tests are designed in such a way to consider the procedural, factual and conceptual knowledge of the learning topic. The tool considers aspects related to both, the learner and the instructor. It generates a diagnostic report to be utilized by the instructor. Moreover, the report suggests remedial advices to enhance process of the learning in cases when the learner experiences severe learning difficulties.

INTRODUCTION:

A developmental perspective of a child is one of important issues in child's growth. As through medical studies it has been demonstrated that inculcation of different types of arithmetic errors in a child stem from selective cognitive disorders. The selective cognitive disorders affect particular areas of the brain of the child and result in impairments of specific aspects of arithmetic knowledge (Geary and Hoard 2001, Gifford 2006, Newman, Griffin and Cole 1989, and Smith 1993). While surveying the available research works the author of the paper (Chronoula and Qaimah 2007), reported that the impairments may affect selectively different aspects of procedural knowledge and knowledge of arithmetical facts because these types of knowledge may develop in a child in a semi-independent way. Further, in the literature (Delazer and Benke 1997, and Lovaas, Ackerman, Alexander, Firestone, Perkins and Young 1981), child's developmental stages and neuro-psychology studies refers to the difficulties with conceptual knowledge in mathematics learning. However, these researchers have been indicated that in general arithmetical facts, procedures and strategies are seem to be most common source of mistakes and putting challenging difficulties during the learning process of arithmetic. Also, they revealed that the wide range of different numerical tasks seem to create challenging difficulties for many children and adults (Hoyson, Jamieson, and Strain 1984, Landerl, Bevan and Butterworth 2004).

Misconceptions associated with numbers, arithmetic difficulties and after effects amongst the children are reported by many researchers (Chronoula and Qaimah 2007, Amar 2007, and Arsham 1998).These researchers identified and reviewed certain misconceptions that are most common among primary and secondary school students. Also Butterworth (2005) reported means of developing of arithmetical abilities of a child.

Hence, on the basis of the above highlighted research reporting's it can be said that perceiving misconceptions in learning plays a vital role in the development of children's mental ability. Therefore, enhancing the learning skills of a child is an essential aspect of educating the child. In designing a course/lesson, identifying the learner's areas of strength, weakness and learning

styles plays an important role. Simultaneously, it should also be kept in mind that different types of memory strategies are being acted upon to store information in the learner's memory according to the mental level. Mainly this memorization strategies fall into three basic categories (Cavanagh 1972, Baddeley, Papagno and Vallar 1988, O'Brien 1994, and Thorn and Page 2008).

- Immediate memory,
- Short-term memory, and
- Long-term memory

Thus, to design effective learning process it is essential to link the evaluation procedures with appropriate types of memory strategies. For example testing through quizzes, midterms and final examinations are being adapted throughout the education systems only because of the above classification of memory strategies. Immediate memorization process, which is linked with testing through quizzes, is one of the most effective as well as the backbone of the learning system. However, proper care must be taken in the learning process through this methodology. If it is not corrected at this particular juncture, it may result in serious repercussions on short and long-term processes of memorization. Visualization can also be used to memorize facts as visual learning methods have a key role in memorization. Using computers in education can therefore enhance the learning process. Computer-based learning processes are quick**,** easy-to-use approach and can be a tool for distant and e-learning (Ahmad, Al-Mashari and Arshad 2003).

Keeping in mind the above facts and the benefits of the information technology in web based education is the main theme of this paper**.** A diagnostic based learning tool is developed. The developed software tool helps both, the learner and the instructor. The tool is capable of designing questions with automated scoring tracking and reporting. Thus, this tool allows focusing on course developments and effective teachings. The tool diagnoses the error pattern and suggests the remedial steps.

Our aim of developing the software is a step in the direction of presenting the idea of diagnostic and/ or conceptual based teaching to enhance the learning process. Further, we want to emphasize that this approach of teaching features to save time and cost along with the mental development of the child.

DIAGNOSTIC BASED TEACHING AND LEARNING PROCESS

During this age, digital technology is used vastly for information transmission, storage and its retrieval in efficient and cost effective manner. The field of education has also been influenced by digital technology. Information Technology (IT) and more over Information Communications Technology (ICT) bring more rich materials into the classrooms and libraries for the teachers and students. It has provided opportunity for the learner to use maximum senses to get the information. It has broken the monotony and provided variety in the teaching – learning situation (Nouri and Shahid 2005). The ICT is being used in almost all levels of education in the areas of teaching, diagnostic testing, remedial teaching, evaluation, psychological testing, development of virtual laboratory, online tutoring, development of reasoning & thinking, and instructional material development (Sansanwal 2009). Further, it is emphasized that ICT helps in improving the quality of teaching via computer based diagnostic testing.

Teaching and Learning Process Based On Diagnostic Assessment

In context to teaching and learning processes, it is noted that many learners who appear to understand a topic at the end of the instruction unit do not retain that even for a few months.

Efficient and more effective long-term learning depends on developing a robust understanding with many connections to other topics and applications. Diagnostic teaching is a process which achieves the goal of efficient and long-term learning. Thus, Diagnostic teaching helps learners to learn, detect, understand and correct misconceptions in their own and their fellow learner's work (Rusbult, 2009).

In the teaching and learning process, usually learners are assessed frequently at different stages for different purposes. The screening, progress monitoring and outcome elements of a comprehensive assessment plan often provide valid and reliable diagnostic information about a child's instructional needs. The diagnostic-based teaching and learning involves an assessment as testing process to gather feedback information about experiencing difficulties by the learner in learning the core concepts. Therefore, it is essential to complete the diagnostic assessments before the instruction plan so as to provide educators with information about each student's prior knowledge before beginning instruction (Johnston and Scott 1991, Kraus and Close 2008 and Sansanwal 2009).

Thus, it can be said that the diagnostic and/or conceptual based teaching serves like a 'First Aid Box', for the learners before bounded to proceed for major operations. This type of teaching by the instructor, first of all, develops the attitude of caring about each child's learning strength. At the other hand diagnostic teaching helps the instructors in planning the sequential lessons of learning processes.

Diagnostic based teaching can only be implemented in effective manner when enough error patterns (syndromes) of the learner's knowledge have been grasped. Analyzing the database of the error patterns one can reach to either any individual or any combination or combinations of the following conclusions.

1. Does the learner make sense of the correct procedure? But however, merely the lack of knowledge and skills of mechanics of notion has led to create the error.
2. Has the learner sufficient knowledge as well as weight of each single step of the procedure?
3. Does the learner understand the operation itself well enough to relate the task to manipulations?

In designing the process of diagnostic based teaching, the following considerations are essentials.

a) The learner must perceive that the instructor is interested in helping the learner.
b) The instructor is willing to accept a response even if it is the erroneous one.
c) In making the diagnosis, one must differentiate between the role of collecting data (test) and the role of teaching.
d) Error patterns should be evaluated in terms of continuity, and, not exactly isolated events.
e) From time to time the direction of remedial should be provided to the learners.

Since the common availability of ICT facilities, currently computer-based diagnostic tests can be simulated easily and can be handled without any skilled staff. Some of the experiments on computer based diagnostic tests indicate that the tests work well and helped the teachers as well as students in identifying the gray area of each and every student. This can be put on the website of the educational institutions and the student can access it from any place at any time. The student can prepare the topic / chapter and can take the test to find exactly what he has not understood? This cannot be accomplished by the teacher manually. The diagnostic tests provide a scope of monitoring student's progress and hence improving the performance of the student.

And, thus it can be concluded that the diagnostic tests intend to develop confidence in students and consequently work towards the change the attitude of learner towards the subject and may start them enjoying learning. There are some hurdles which restricts the use of computer based diagnostic tests in teaching. Some examples include the competency of teacher in developing and administering diagnostic tests and the cost (Sansanwal 2009). Inspired by the attributes of computer based diagnostic tests we present this paper and report the development of a user-friendly software tool to accomplish the objective of teaching and learning process. This software will serve the purpose of an on-line diagnostic based teaching. Further, the developed software will be more pronounced in the age of e-education and e-learning.

SOFTWARE DEVELOPMENT

A diagnostic based learning software tool was developed using a graphical user interface environment design language 'visual basic'. The basic tool window is set with all kinds of the user interacting features like managing project / file, reset, exit, error, warning, yes, no, ok, help, hand menu, and etc. The help menu provides the knowledge of - How to use? Further, the software has an authenticated process of registration. The software has several security arrangements such as a wide range of passwords selections based on pseudo-random sequences (PN - sequences). Figure 1 presents a partial window view of the software. Also, based on the results of the learner a necessary report is automatically generated and forwarded to the teacher. At the other hand the encouragement or suggestion messages such as 'excellent', working good' 'awarded a gold/ bronze / silver medal', 'meet your teacher' are conditionally set on the basis of the defined diagnostics.

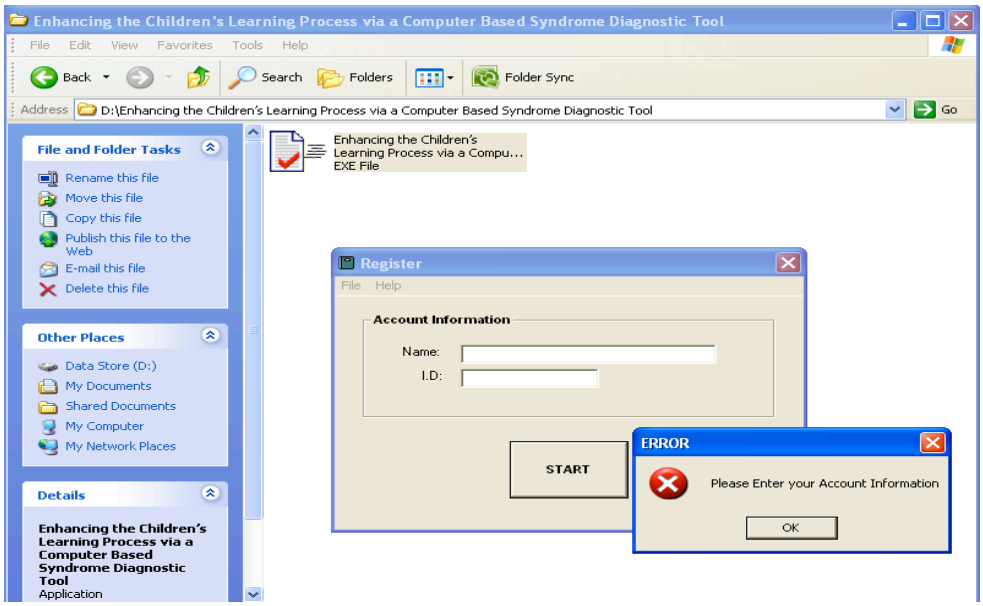

Figure 1: Partial window view of the software

Based on an algorithmic approach a proto-type model of the software was developed. It considers not only evaluation procedure but also, provides the diagnostic approach of learning. The software incorporates the procedure to keep track of strength and weaknesses. The software

via repeated diagnostic tests may help in monitoring the improvement in the learning process of the learner. Since of the four basic arithmetic operations addition seems to present the least challenges to the children, the first experimental result was based on addition skill. Since the developed software required designing the syndromes on the basis of the error patterns therefore, this experiment took place in a nursery school with the children learning basic numeracy and arithmetic.

Amongst children probably there exist two most common errors relate to addition are the positioning of the numbers in the vertical presentation of the addition and the process of 'carrying'. Both of these errors are symptomatic of a lack of understanding of place value. On the basis of our experiments we found some other kinds of error patterns like 'adding from left to right', 'missing concepts of place values of digits', 'problem in addition with unequal number of digits' we designed the addition problems. The software incorporates twenty addition problems (ADD-1 to ADD-20). These problems are arranged in four sheets (SHEET-1 – to SHEET-4) containing five addition problems in each sheet. These addition problems are shown below as Tables 1 - 4.

Table 1: Template SHEET 1

ADD-1	ADD-2	ADD-3	ADD-4	ADD-5
93	72	64	75	21
+ 87	+ 41	+ 29	+ 96	+ 11

Table 2: Template SHEET 2

ADD-6	ADD-7	ADD-8	ADD-9	ADD-10
132	73	768	652	321
+ 531	+ 84	+ 283	+ 477	+ 123

Table 3: Template SHEET 3

ADD-11	ADD-12	ADD-13	ADD-14	ADD-15
3	6	4	31	42
+ 4	+ 13	+ 23	+ 2	+ 26

Table 4: Template SHEET 4

ADD-16	ADD-17	ADD-18	ADD-19	ADD-20
57	6	1	3	13
+ 7	+ 42	+ 21	+ 2	+ 2

DESIGN OF SYNDROMES FROM THE ERROR PATTERNS

Following are some examples illustrating the capabilities of the software. Examining the work examples in (Tables 5 – 8) carefully, we notice that Sheet-1a is completed by a child who knows how to add but the concept of carryover is missing. The error pattern and the correct answers of SHEET-2a reflects that the child is aware of the concept of addition but missing is the place values of digits and starts adding from left to right. The answer patterns also indicate that the student is fine with the carryover concept. Analyzing the work submission in Sheet-3a, we find that the child is aware of the addition process confused when the number of digits in adding number differs. In this situation of unequal number of digits the student adds all the digits together. Interestingly, the error patterns of Sheet-4a reflect that the child knows addition, has clear concept of carryover process but when the numbers of digits in the adding numbers are not same then the child answers incorrectly. The child makes both the numbers with the equal number of digits and for doing so by repeating the digit. The answers of Sheet-4 also reflect that the child does not know about the place values of the digits. The error syndromes are identified by 5-bit binary numbers starting from $(00000)_2$ – $(10011)_2$ which covers all the 20 syndromes (Syndrome 1 – Syndrome 20). The syndromes are judged by the binary options and simultaneously Exclusive-ORed first by the correct answer and if the value is zero then it is defined as particular syndrome (no error) as “Correct”. In case of Exclusive-OR operation if the result is not zero this indicates that error exists hence it is further investigated for the particular nature of the syndrome.

Table 5: Response of Template SHEET 1

ADD-1	ADD-2	ADD-3	ADD-4	ADD-5
93	72	64	75	21
+ 87	+ 41	+ 29	+ 96	+ 11
1710	113	813	1611	32

Table 6: Response of Template SHEET 2

ADD-6	ADD-7	ADD-8	ADD-9	ADD-10
132	*1* 73	*1* 768	*11* 652	321
+ 531	+ 84	+ 283	+ 477	+ 123
663	58	9412	0310	444

Table 7: Response of Template SHEET 3

ADD-11	ADD-12	ADD-13	ADD-14	ADD-15
3	6	4	31	42
+ 4	+ 13	+ 23	+ 2	+ 26
7	10	9	6	68

Table 8: Response of Template SHEET 4

ADD-16	ADD-17	ADD-18	ADD-19	ADD-20
1 57	6	1	3	13
+ 7	+ 42	+ 21	+ 2	+ 2
134	108	32	5	35

RUN OF SOFTWARE

At its infancy stage this developed software was hooked with the class room computer and the individual student was asked to appear for the test in presence of an invigilator other than the instructor of the class. A sample of a run of the software is presented in this section. As an example presented here is Figure 2 which shows the working template for the last sheet (Sheet 4) of the graphical user interface program. At the end of submission of Sheet 4 a message box is programmed to inform the learner 'Done!' along with the thanks and instruction 'Thank you! Consult Your Instructor for Results'. The execution of the program generates the reports as partially demonstrated in Figure 3 (report of result of only Sheet 1 is presented) and Figure 4 (a syndrome report to the instructor). Figures 3 and 4 shown below are the reports generated on the basis of the answers of the learner 'Student1, with registration password ID # 1234, along with the date and time of the examination. The reports based on the work of another learner 'Student2 with ID#: 2345 are presented in Figures 5 and 6. Note that the tables do not contain a complete report since it is difficult to show on a single page.

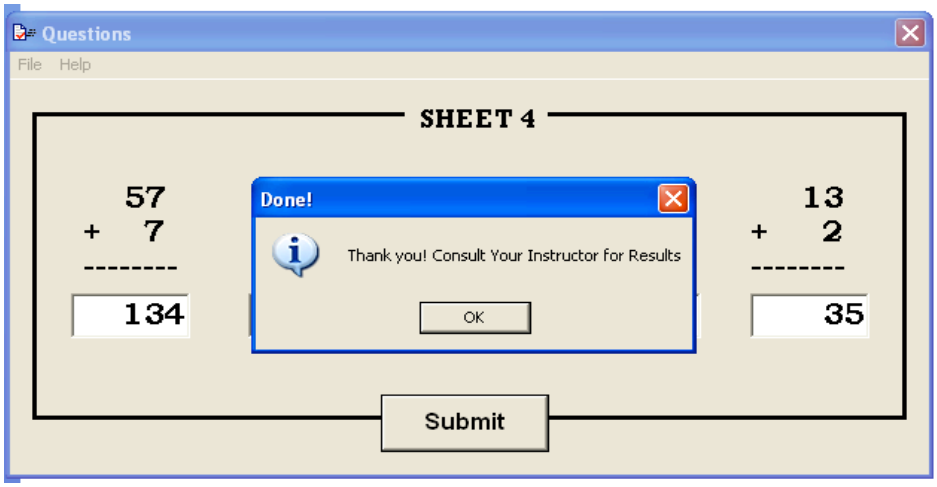

Figure 2: Working Window Templates

```
================================================
== Student Name: STUDENT1
== ID #: 1234
== Date & Time of Exam: 19.03.2009   06:10 PM
==
================================================
| Q# | Correct Answer | Student Answer | Status |
------------------------------------------------
| 1  |     180        |     180        |Correct |
------------------------------------------------
| 2  |     113        |     113        |Correct |
------------------------------------------------
| 3  |     93         |     93         |Correct |
------------------------------------------------
| 4  |     171        |     171        |Correct |
------------------------------------------------
| 5  |     32         |     32         |Correct |
------------------------------------------------
```

Figure 3: A Partial Report Generated for Student1, ID# 1234

```
    Start syndrome processing in given answers

                  Sheet 1
                 ========

    No Error Pattern found
================================================

                  Sheet 2
                 ========

    No Error Pattern found
================================================

                  Sheet 3
                 ========

    No Error Pattern found
================================================

                  Sheet 4
                 ========

    No Error Pattern found
================================================


                  Statistics
                 ============
    Total of Correct Answers =  20
    Percentage of wrong Answers =  0  %
    Percentage of questions attempted =  100  %
================================================

               End of Process
================================================
```

Figure 4: A Syndrome Report Generated for Instructor for the Case of Student1, ID# 1234

```
==================================================
== Student Name: STUDENT2
== ID #: 2345
== Date & Time of Exam: 19.03.2009   11:46 PM
==
==================================================
| Q# | Correct Answer | Student Answer | Status    |
--------------------------------------------------
| 1  |     180        |     1710       |syndrome1  |
--------------------------------------------------
| 2  |     113        |     113        |Correct    |
--------------------------------------------------
| 3  |     93         |     813        |syndrome3  |
--------------------------------------------------
| 4  |     171        |     1611       |syndrome4  |
--------------------------------------------------
| 5  |     32         |     32         |Correct    |
--------------------------------------------------
| 6  |     663        |     663        |Correct    |
--------------------------------------------------
| 7  |     157        |     58         |syndrome7  |
--------------------------------------------------
| 8  |     1051       |     9412       |syndrome8  |
--------------------------------------------------
| 9  |     1108       |     19         |syndrome9  |
--------------------------------------------------
| 10 |     444        |     444        |Correct    |
--------------------------------------------------
| 11 |     68         |     68         |Correct    |
--------------------------------------------------
| 12 |     33         |     6          |syndrome12|
--------------------------------------------------
| 13 |     27         |     9          |syndrome13|
--------------------------------------------------
| 14 |     7          |     7          |Correct    |
--------------------------------------------------
| 15 |     19         |     10         |syndrome15|
--------------------------------------------------
| 16 |     64         |     134        |syndrome16|
--------------------------------------------------
| 17 |     48         |     108        |syndrome17|
--------------------------------------------------
| 18 |     22         |     32         |syndrome18|
--------------------------------------------------
| 19 |     5          |     5          |Correct    |
--------------------------------------------------
```

Figure 5: A Partial Report Generated for Student2, ID# 2345

```
==========================================================


    Start syndrome processing in given answers

                   Sheet 1
                  ========

    Error found Pattern diagnoses: carryover concept missing
==========================================================

                   Sheet 2
                  ========

    Error found Pattern diagnoses: Adds left to right
==========================================================

                   Sheet 3
                  ========

    Error found Pattern diagnoses: adding digits together -
    horizontal addition,place value concept
==========================================================

                   Sheet 4
                  ========

    Error found Pattern diagnoses: vertical addition
    concept,place value concept
==========================================================


                   Statistics
                  ============
    Total of Correct Answers =  07
    Percentage of wrong Answers =  65  %
    Percentage of questions attempted =  100  %
==========================================================

                End of Process
==========================================================
```

Figure 6: A Syndrome Report Generated for Instructor for the Case of Student2, ID# 2345

CONCLUSIONS

An educational tool compatible with e-education and e-learning platforms was developed with the aim to help learner through diagnosed difficulties. The tool has the capability of testing a learner's ability to answer the questions correctly by evaluating the response automatically and subsequently generating a list of weaknesses or errors found. This feedback can be used by the instructor to improve the learner's skills by focusing on the reported weaknesses. Practical examples were demonstrated to show the capabilities of the developed tool. The demonstrated examples were restricted to addition arithmetic; however, the tool's capability is much stronger and versatile. Overall this was an example in the direction of designing the ICT tool based on diagnostic tests. The idea of this study can be easily extended to any subject/ class with the developed concepts.

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